EXTREME PRECIPITATION: CURRENT FORECAST ABILITY AND CLIMATE CHANGE

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I. INTRODUCTION

Extreme precipitation events are a major cause of flooding events, such as the 2007 summer floods in the UK and other flooding events in Western Europe. Such events are difficult to forecast due to the convective scale processes embedded within the synoptic scale.

The effect of climate change of such events also needs to be addressed. In a warmer climate, the frequency and intensity of extreme events are projected to increase. If similar synoptic conditions as seen in 2007 over the UK are experienced in a future climate, how extreme will the precipitation be, and will such conditions become more frequent?

This research uses a Limited Area Model (LAM) of the UK Met Office's Unified Model at a 12km resolution, to investigate the current forecast ability of extreme precipitation. The ECHAM5 Global Climate Model (GCM) at high resolution (T213/T319) is also used to investigate the change in Atlantic storm tracks in a warmer climate.

II. CURRENT FORECAST ABILITIES

The UK floods experienced during the summer of 2007 were caused by extreme rainfall from local convective storms. These storms were persistent over the UK due to the presence of a stationary cut-off low that remained over the UK for several days, bringing a constant moisture supply to the convective storms (Blackburn, 2008).

The small scale of the convective systems, embedded within the synoptic scale system, meant it was very difficult for the forecast model, which at the time had a resolution of 12km, to pick up the extreme rainfall. Figure 1 shows the precipitation output for a LAM re-run for the summer 2007 UK floods using ECMWF boundary conditions.

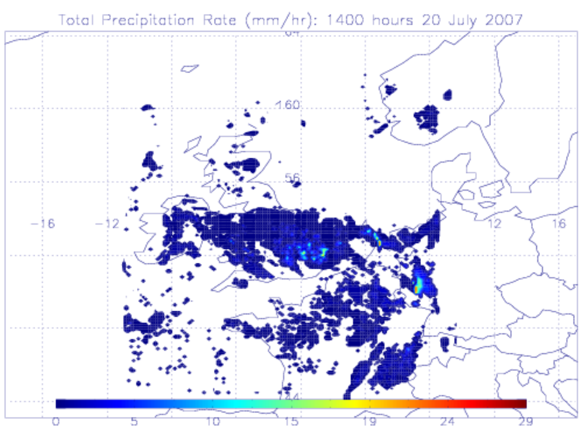

FIG. 1: Total Precipitation Rate output from a 12km v6.1 LAM of the UK Met Office's UM at 1400 hours for the 20th July with ECMWF boundary conditions.

Figure 2 shows the radar imagery at the same time, which has a resolution of 1km, from the Met Office NIMROD radar network. Figure 1 shows that the LAM picks up the large scale seen in the radar imagery, but does not pick up the small scale, or the intensity seen in the radar imagery.

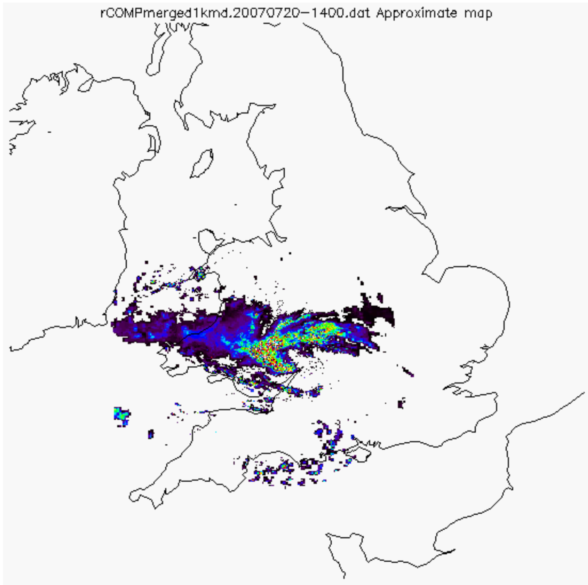

FIG. 2: UK Met Office C-band rainfall radar data, for use with the NIMROD automated weather analysis and nowcasting system, for the 20th July 2007 at 1400.

The 12km resolution of the LAM does not have a high enough resolution to model the convective systems. This would explain why during the 2007 floods, the model under-predicted the amount of rainfall by up to 45% of the observed rainfall (Stuart-Menteeth, 2007).

However, as noted by Nieto et al., 2005, the precipitation distribution associated with cut-off lows is difficult to predict as they bring moderate to heavy rainfall over large areas. Therefore an increase in resolution does not necessarily mean an improved forecast for such conditions.

III. GLOBAL CLIMATE MODELS

The ECHAM5 T319 GCM is used to investigate whether the intensity and frequency of Atlantic storms change in a warmer climate. This has been investigated by Bengtsson et al. (2009) at the T213 resolution; however a higher resolution model is expected to predict more extreme events.

Storms are tracked using the TRACK software developed by Hodges (1995) which tracks storms based on their 850hPa relative vorticity. The tracking was performed for two periods: a 20th Century (20C) climate, 1980-2000, and a 21st Century (21C) climate, 2080-2100, using the IPCC A1B scenario for the 21C.

Figure 3 shows the maximum precipitation along the tracks determined as the area averaged precipitation within 5 degree of the storm centre, for DJF and JJA, for both the T319 and T213 resolutions. The insets show the tails of the distributions scaled to 90 months.

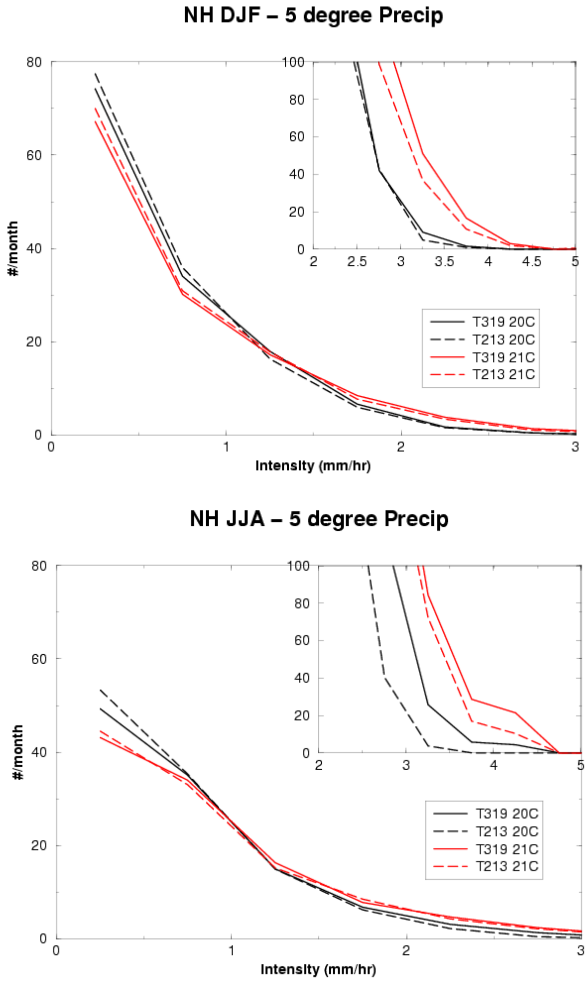

FIG. 3: Comparison of T213 (dashed) and T319 (solid) intensity distributions for area (5 degrees) averaged total precipitation rate (mm hr^{-1}), bin width is 0.5 mm hr^{-1}, for 20C (black) and 21C (red) for the Northern Hemisphere for DJF (top) and JJA (bottom).

Figure 3 shows that in the T319 resolution, in comparison to the T213 resolution, there is an increase in the number of extreme events. This increase is a lot smaller for DJF than JJA. Figure 3 also shows an increase in the number of extreme events in 21C, in comparison to 20C, for both DJF and JJA. This appears larger in T319.

IV. CONCLUSIONS

The resolution of weather forecast models has increased in recent years, from 12km to 1.5km (UK Met Office). The benefit of this increase in resolution on cut-off low events, such as the summer 2007 UK floods, needs to be investigated, to determine whether the higher resolutions are able to forecast convective storms when embedded within a larger scale storm.

It is also clear that the number of extreme precipitation events is expected to increase in a warmer climate, and also for the intensity of these events to increase. It is planned to track cut-off lows in the ECHAM5 data, using the TRACK software. By selecting a case study identified in this data, and downscaling it to use as boundary conditions for a LAM, the effect of the increase in intensity can be investigated.

V. REFERENCES

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